KLOE EMC SIMULATION WITH FLUKA

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for the FLUKA-in-KLOE group

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The KLOE calorimeter

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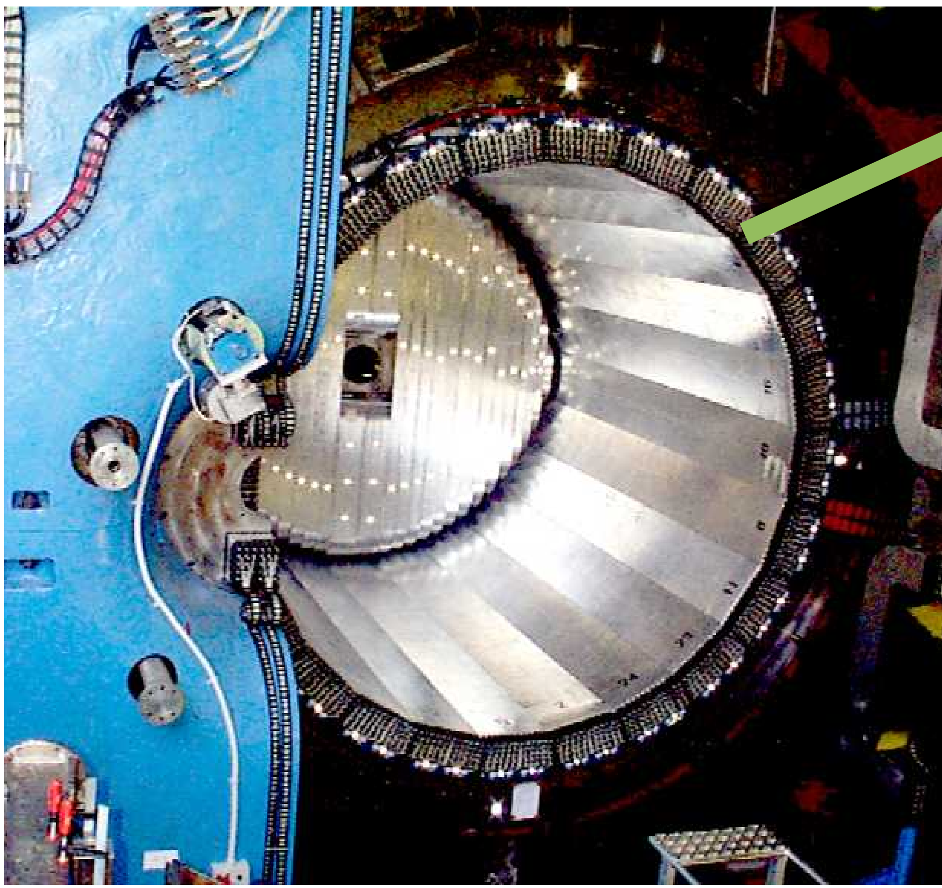
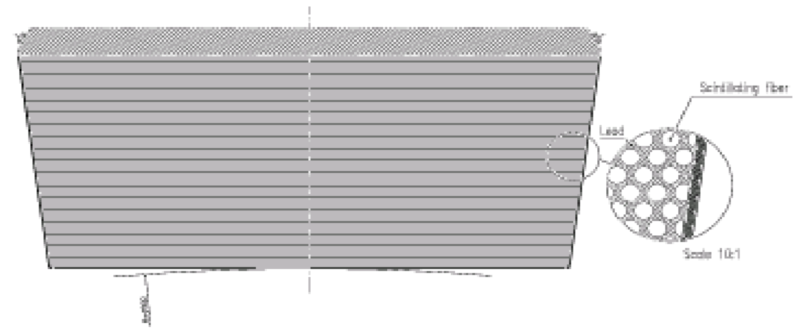


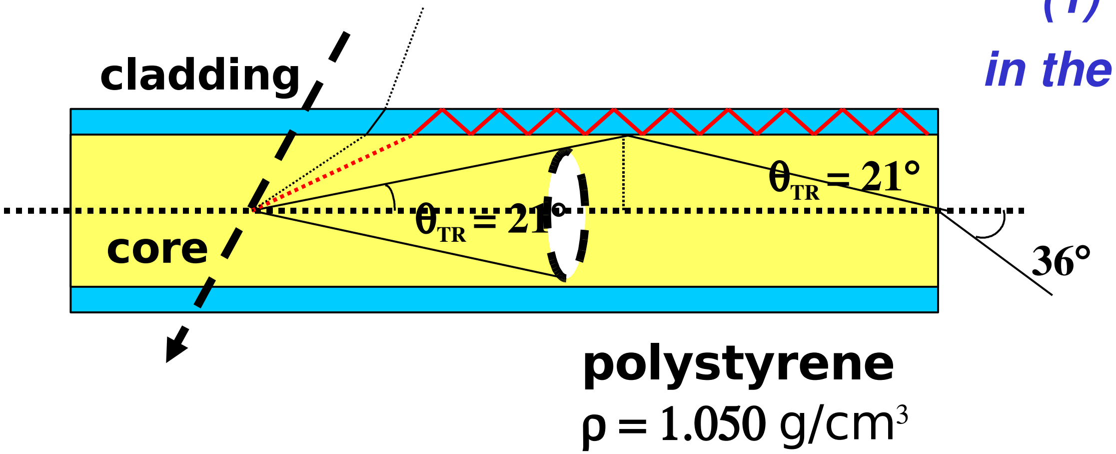
Calorimeter module



24 barrel modules
Trapezoidal section
(52 – 59)x23 cm^2
length: 430 cm

Pb/Sci fibres structure
200 layers, lead foils + glue + fibres

Working principle



(1) Scintillating fiber (1mm diameter) [emitting in the blue-green region (λ_{peak}~460 nm)]

(2) Lead: 0.5mm grooved layers (95% Pb and 5% Bi)

(3) Glue: Bicron BC-600ML (72% Epoxy resin, 28% Hardener)

n(core=**polystirene**) = **1.6** n(cladding=**PMMA**) = **1.49**

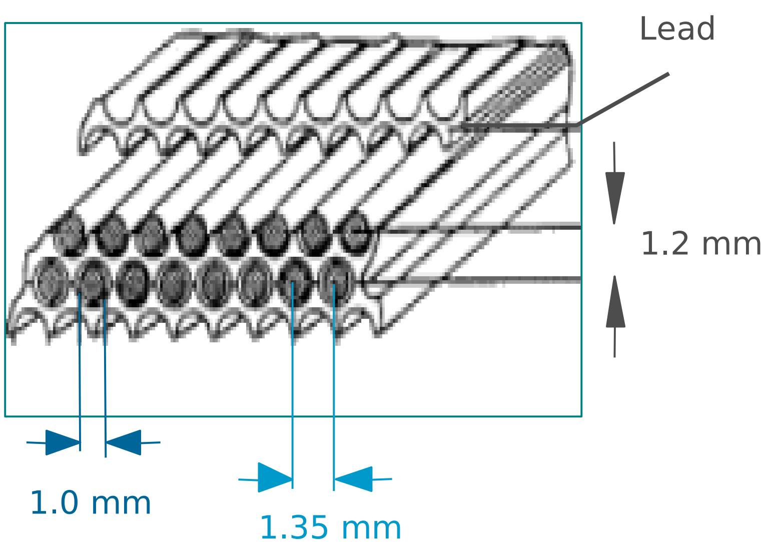
Only ~**3%** of photons produced are trapped in the fiber

But :

(a) ~ uni-modal propagation at **21°** ➔ small transit time spread

(b) Small attenuation (λ ~ **4-5 m**)

(c) Cladding light removed by optical contact with glue n(glue) ~ n(core)



Fibers used: *Kuraray SCSF-81* *Pol.Hi.Tech. 00046*

15.000 km of fibers

(fully tested: *A.Antonelli et al., NIM A370 (1996) 367*)

Material simulation and compounds

Active material (fibres+cladding)

Polystyrene C_2H_3 homogeneous material

average density between cladding and core $\rho = 1.044\ g/cm^3$

Passive material

Lead foils: 95% Pb 5 % Bi homogeneous compound

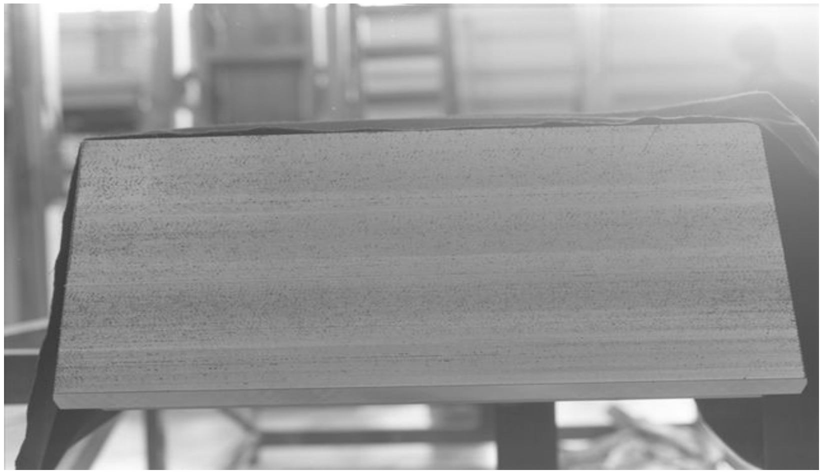
Glue:

- 72% Epoxy resin C_2H_4O ($\rho = 1.14\ g/cm^3$)
- 28% Hardener ($\rho = 0.95\ g/cm^3$)

Polyoxypropylediamine	$C_7H_{20}NO_3$	90%
Triethanolamine	$C_6H_{15}NO_3$	7%
Aminoethylpiperazine	$C_6H_{15}N_3$	1.5%
Diethylenediamine	$C_4H_{10}N_2$	1.5%

Calorimeter module structure

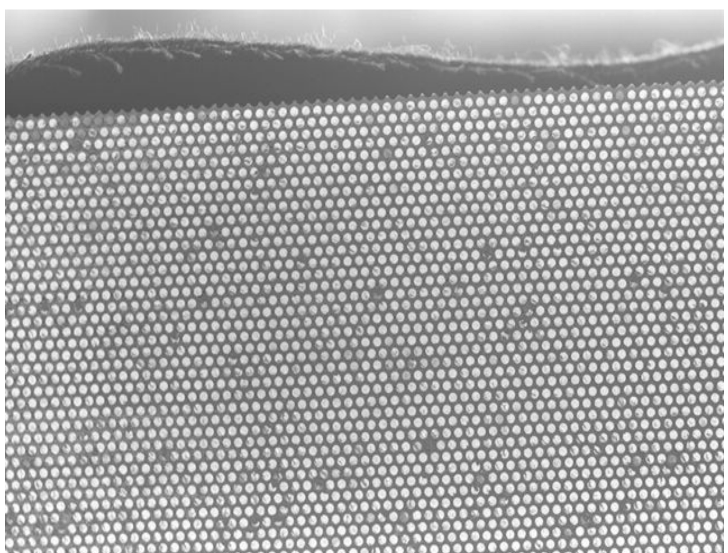
Transversal section



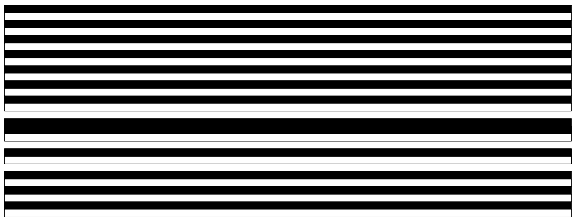
Low attenuation length

The image at one side of the module is projected through the fibres on the opposite side.

Fibres structure is visible



Structure simulation



Old simulation:
Lead–Sci-fibres layers GEANT3

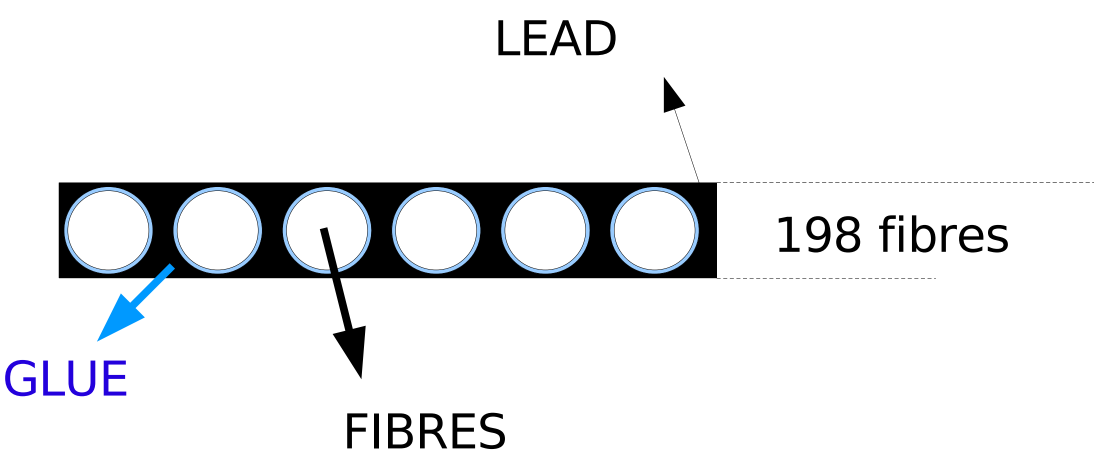
FLUKA simulation

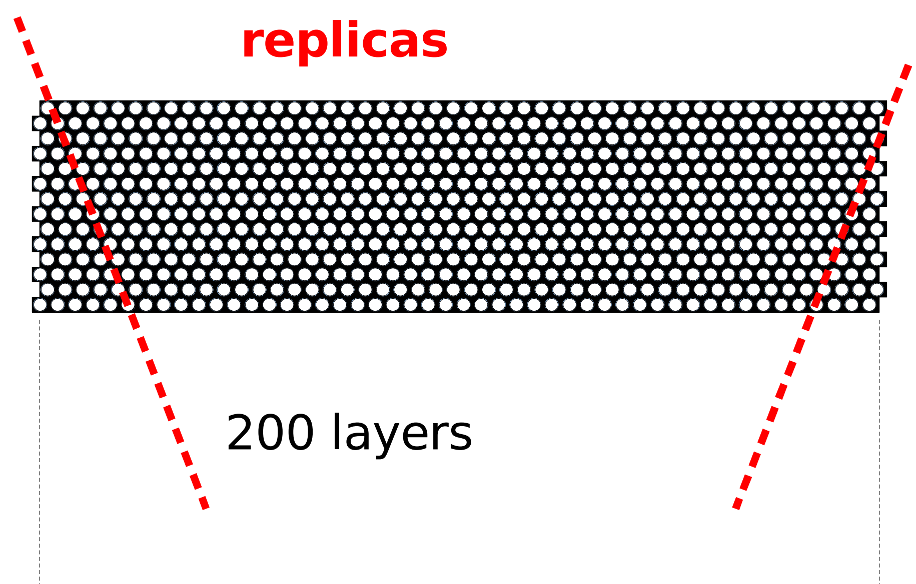
Using lattice tool the fibre structure can be easily designed.

Can we use combinatorial geometry to design a trapezoidal structure?

PLA

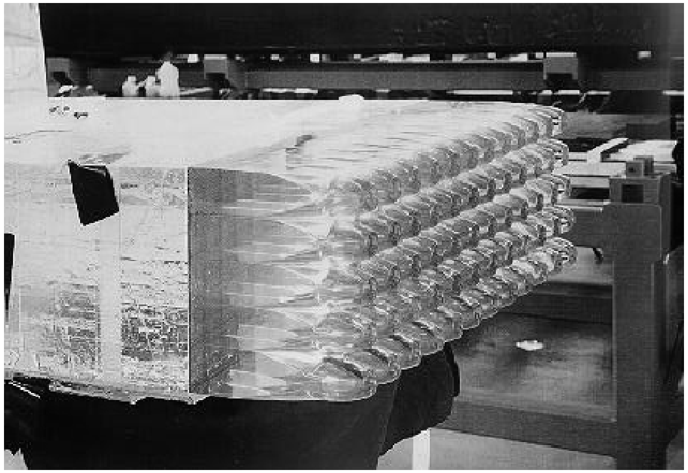
base module



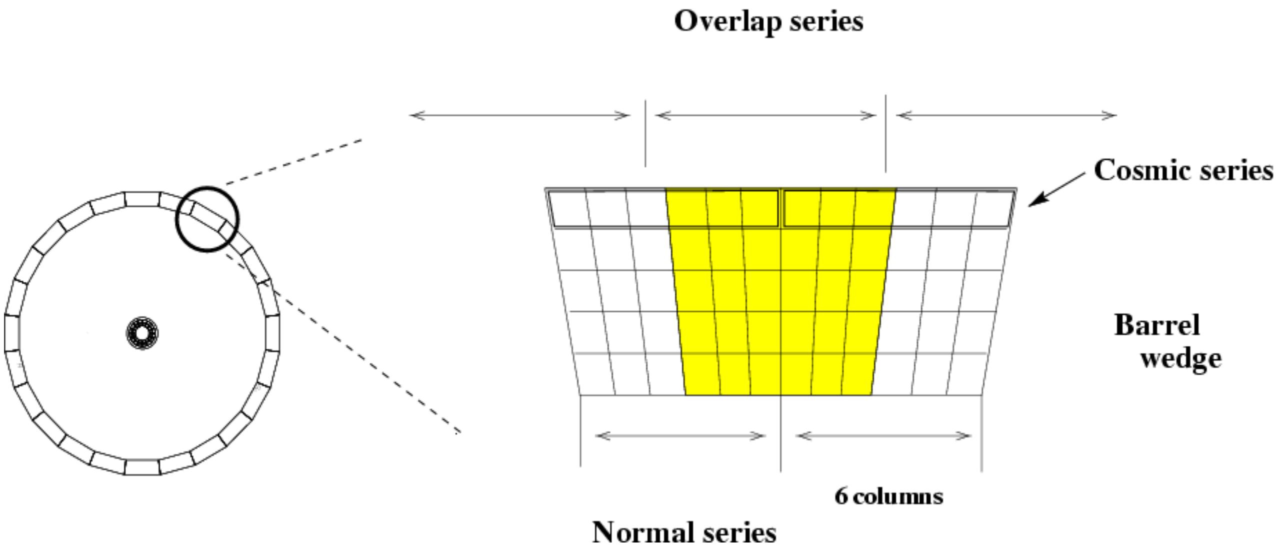


Read out system

Plexiglas light guides (**n=1.6**, **20 cm** length [Winston cone])
glued on both sides (after milling) ➔ **4.4 X 4.4 cm²** granularity:

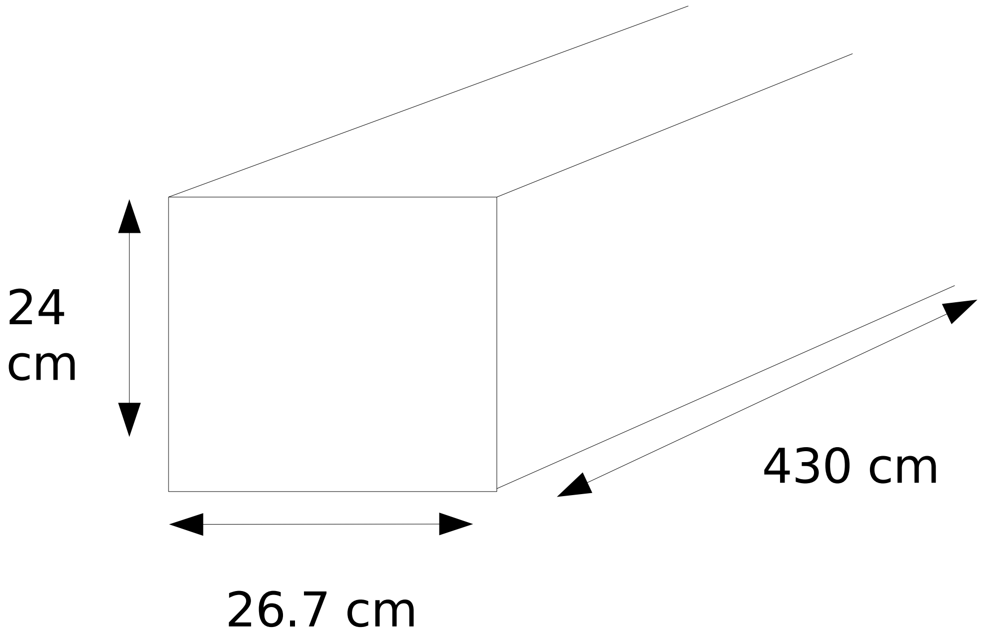


Fine-mesh photomultipliers **(1.5')**
Hamamatsu **R5960**
Working in **B=0.1-0.2T** and **0 < θ < 30°**
(**Q.E.~25%** , **G~5 x10⁶**)

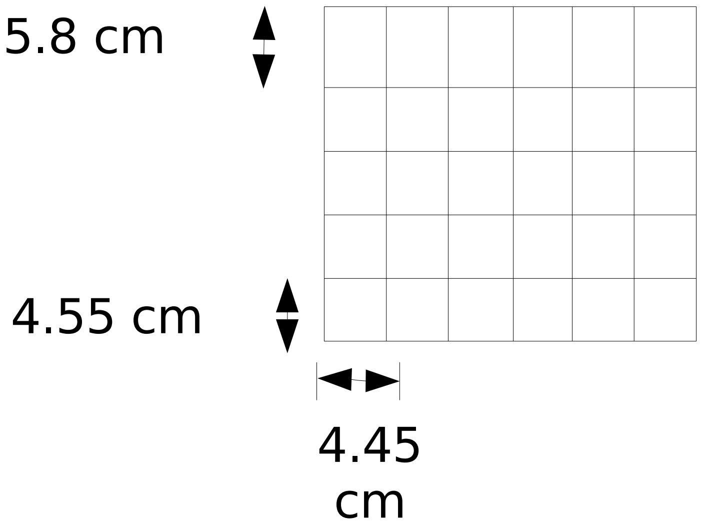


Geometry simulation status

simulated module

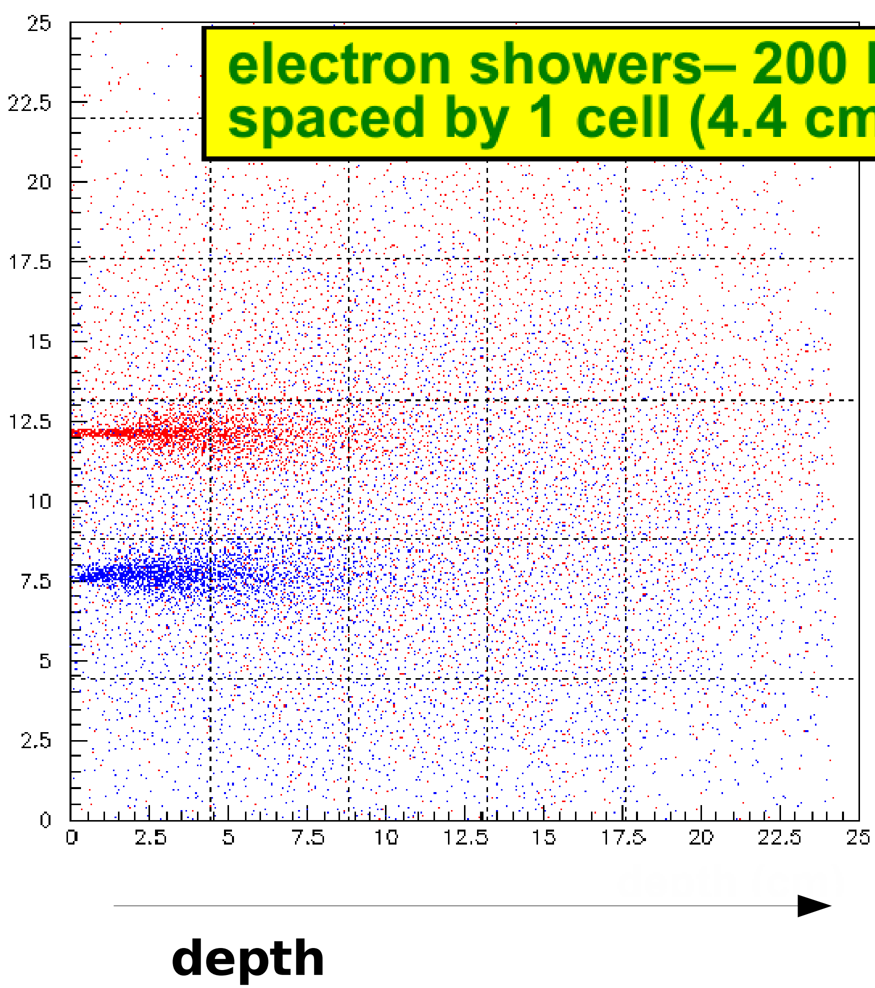


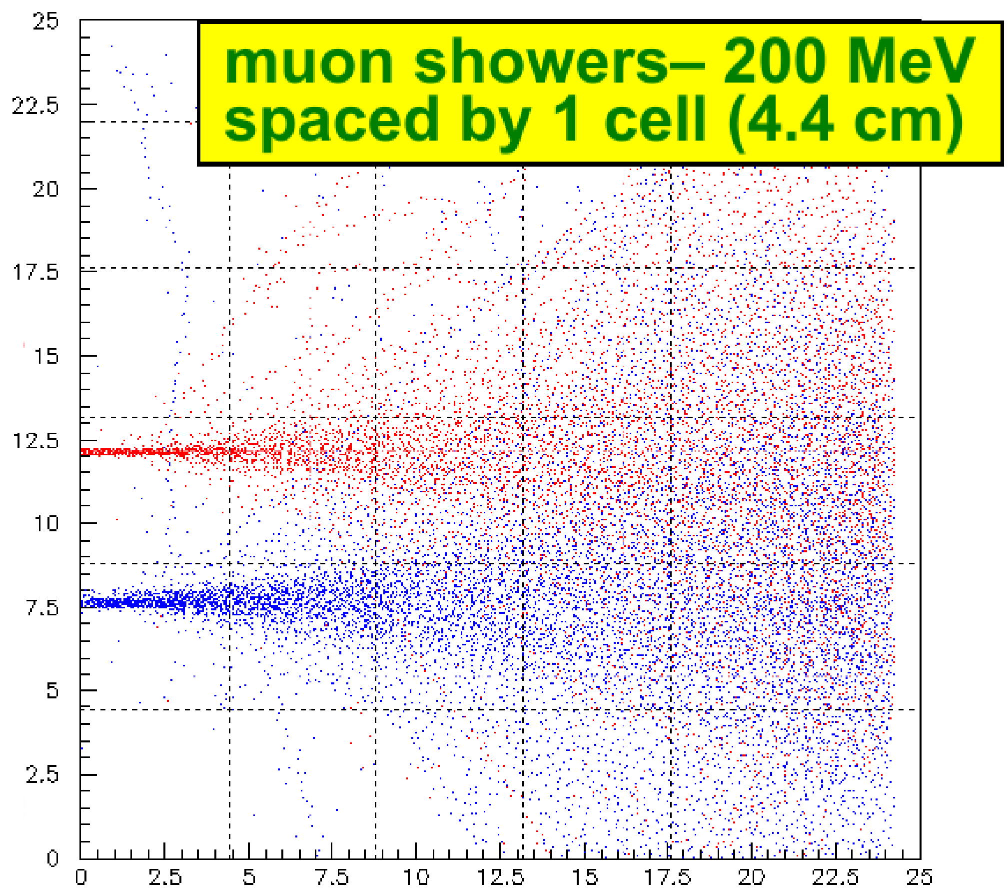
readout scheme



Preliminary study
full simulation of the whole calorimeter in program

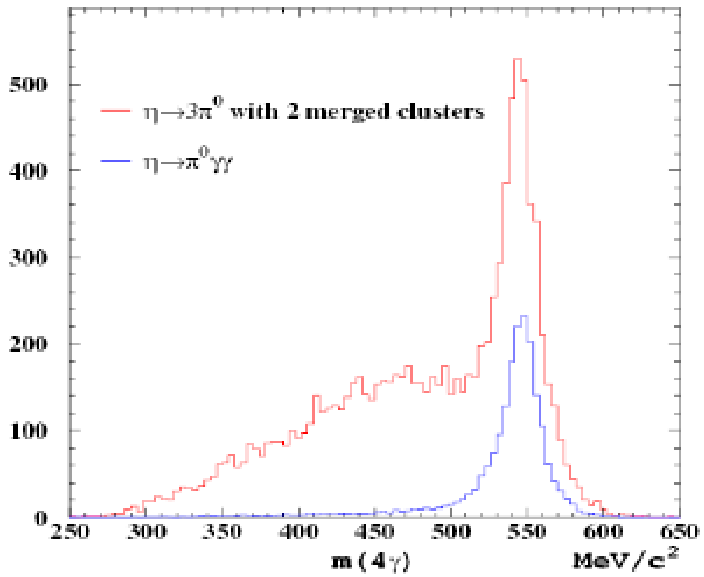
Energy deposits in the fibres





Granularity study for merging effect evaluation

Cluster merging effect: the $\eta \to \pi^0\gamma\gamma$ decay



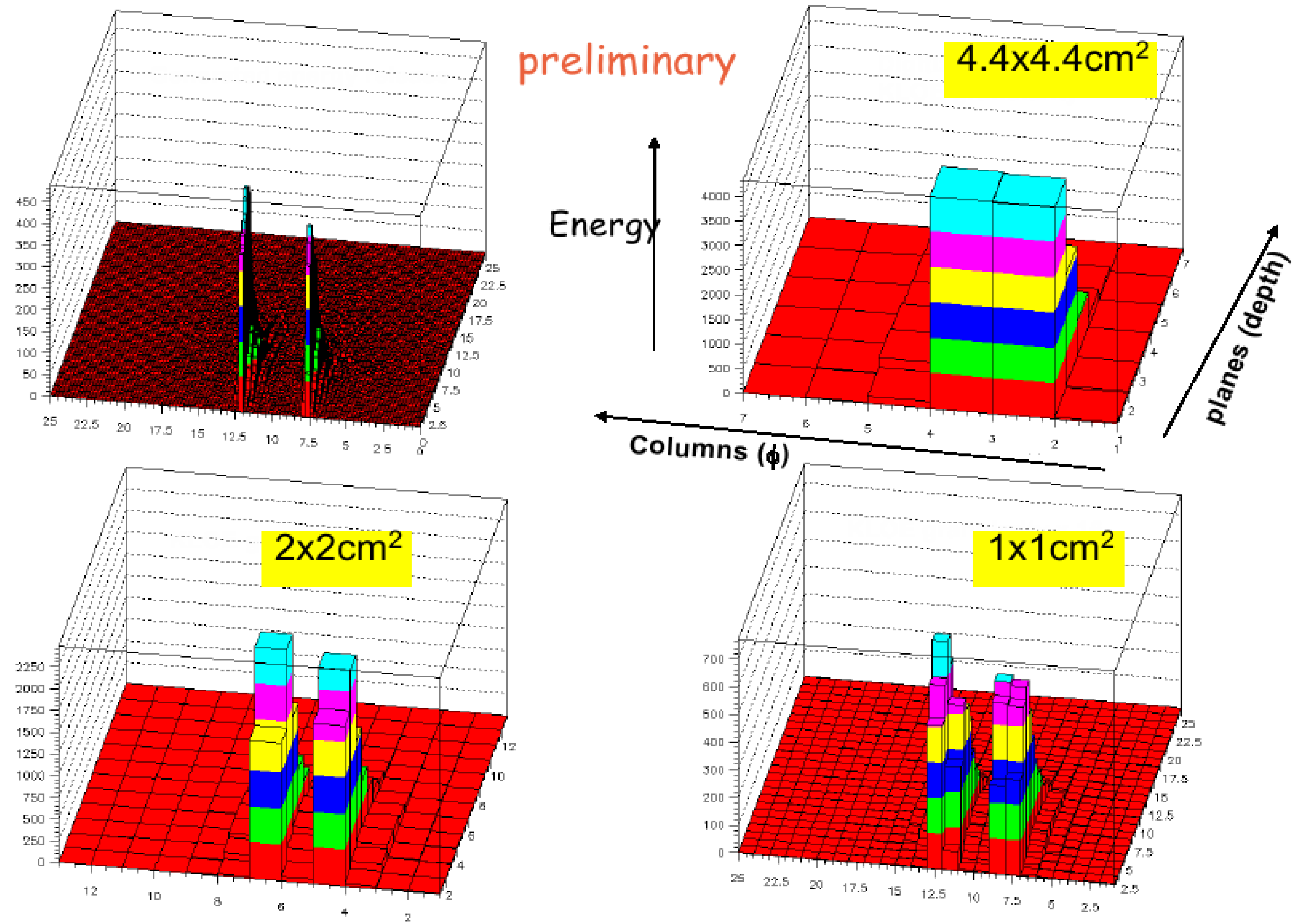
After cutting on the kinematic fit χ^2 in the $\phi \to \eta\gamma \to \pi^0\gamma\gamma\gamma$ hypothesis, a huge background survives, entirely due to $\eta \to 3\pi^0$ decays with double merged clusters.

Due to the merging of two couple of photons the topology of $\eta \to 3\pi^0$ becomes equal to the $\eta \to \pi^0\gamma\gamma$. The invariant mass of the four photons peaks as the signal. The two plots are scaled according the real branching ratios:

By integrating only the mass peak region we get $\frac{signal}{background} = 0.35$

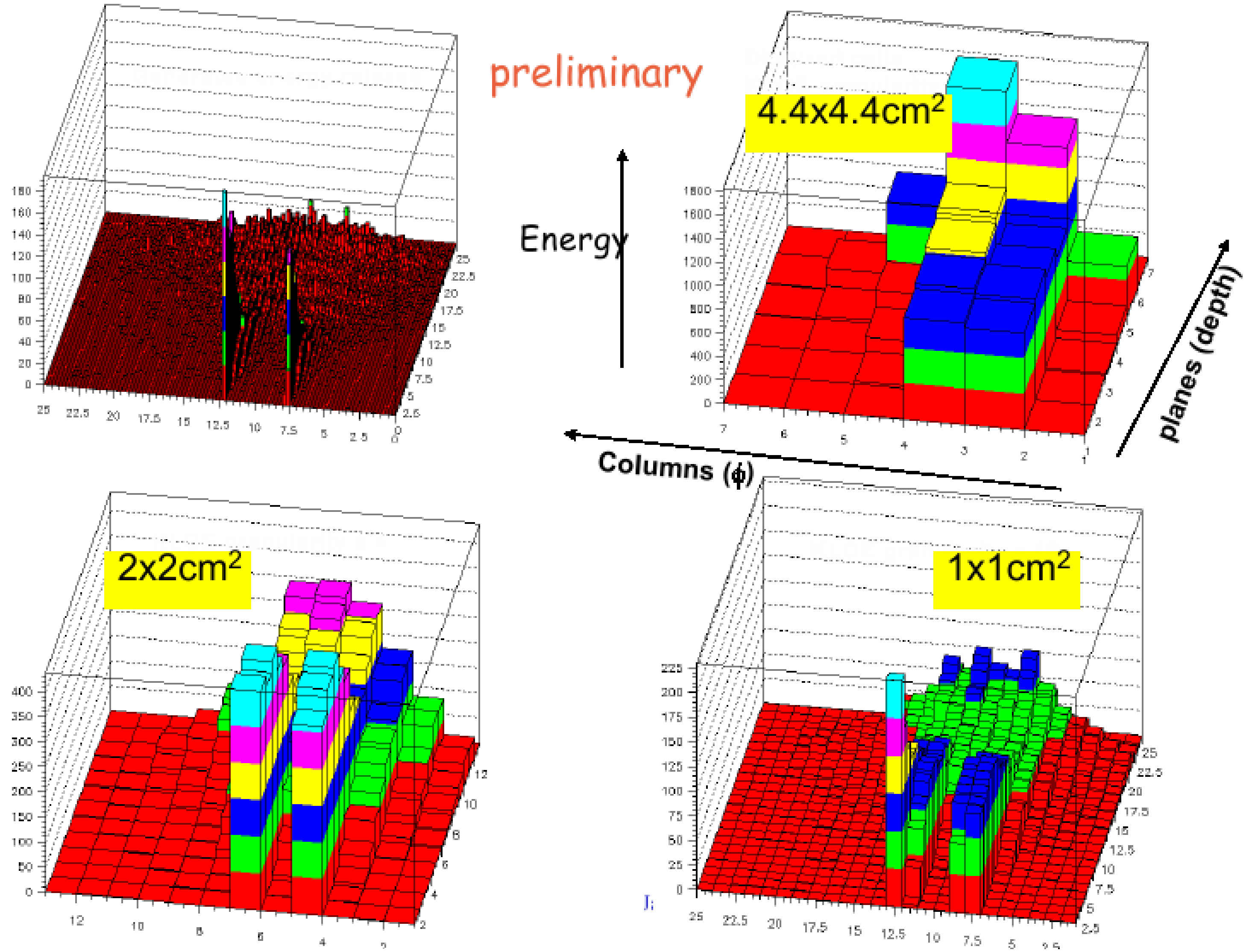
Granularity study for merging effect evaluation

Granularity tests with 1000 events with two 200 MeV electrons



Granularity study for merging effect evaluation

Granularity tests with 1000 events with two 200 MeV muons

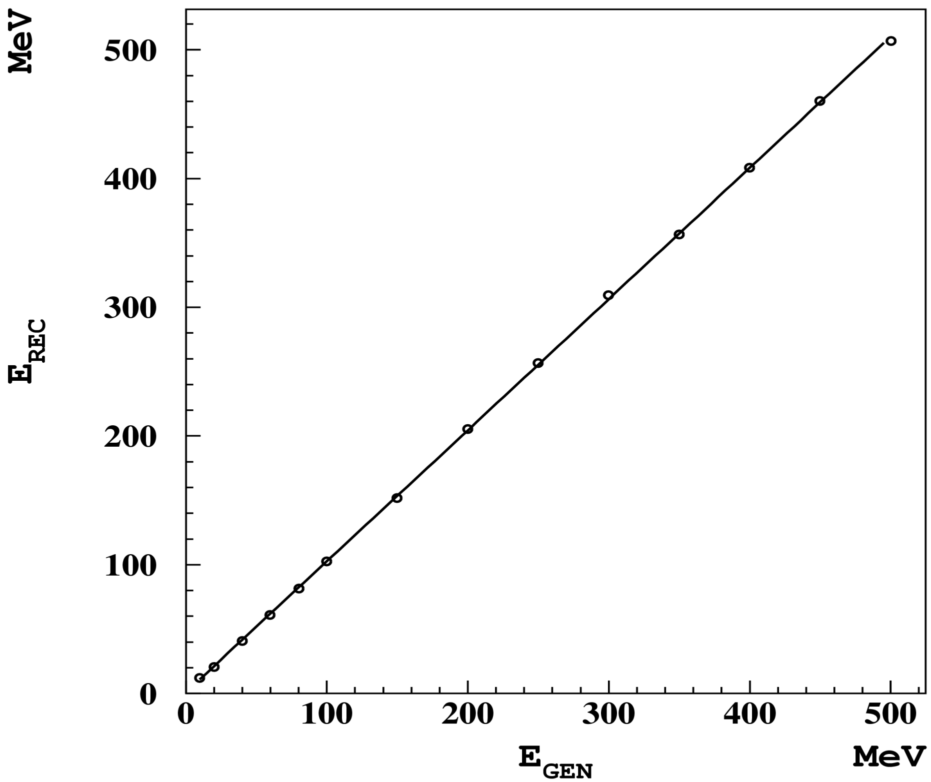


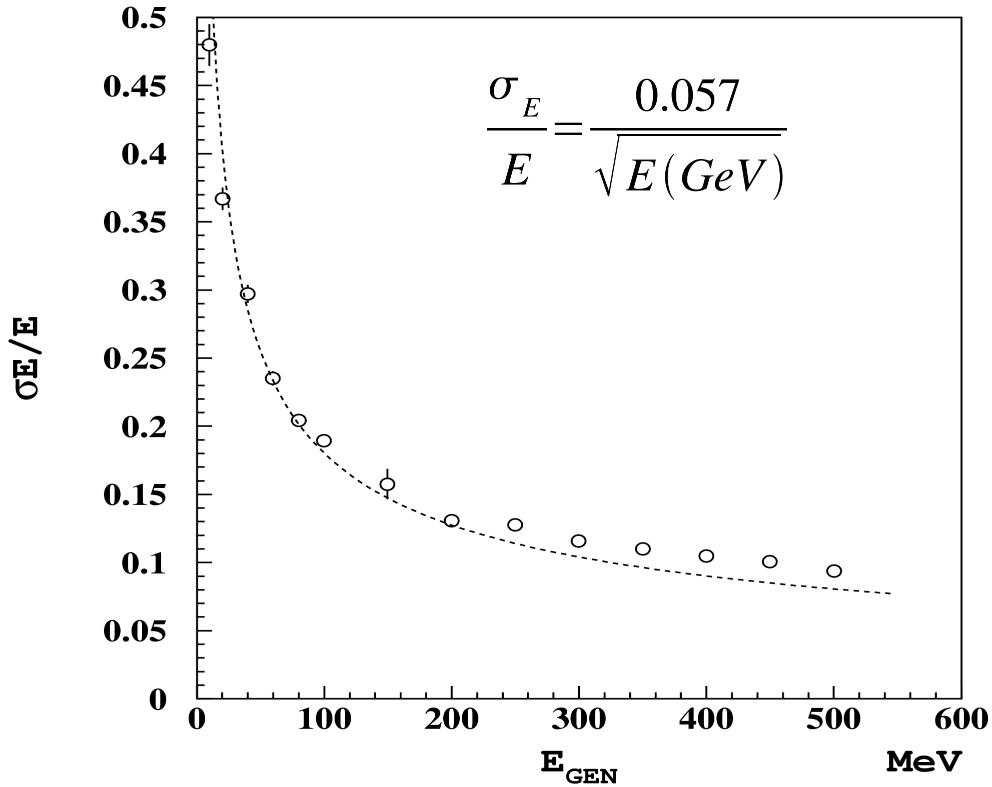
COMPARISON WITH DATA -PHOTON RESPONSE

Energy response

linearity response well reproduced

The curve is the known detector resolution, dots FLUKA simulation

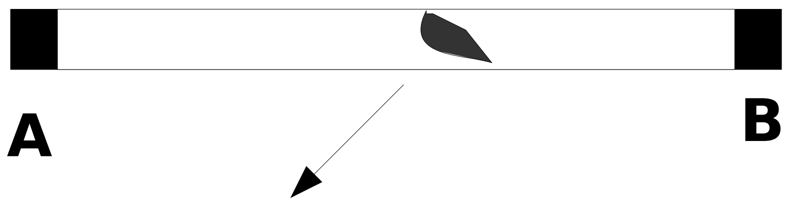




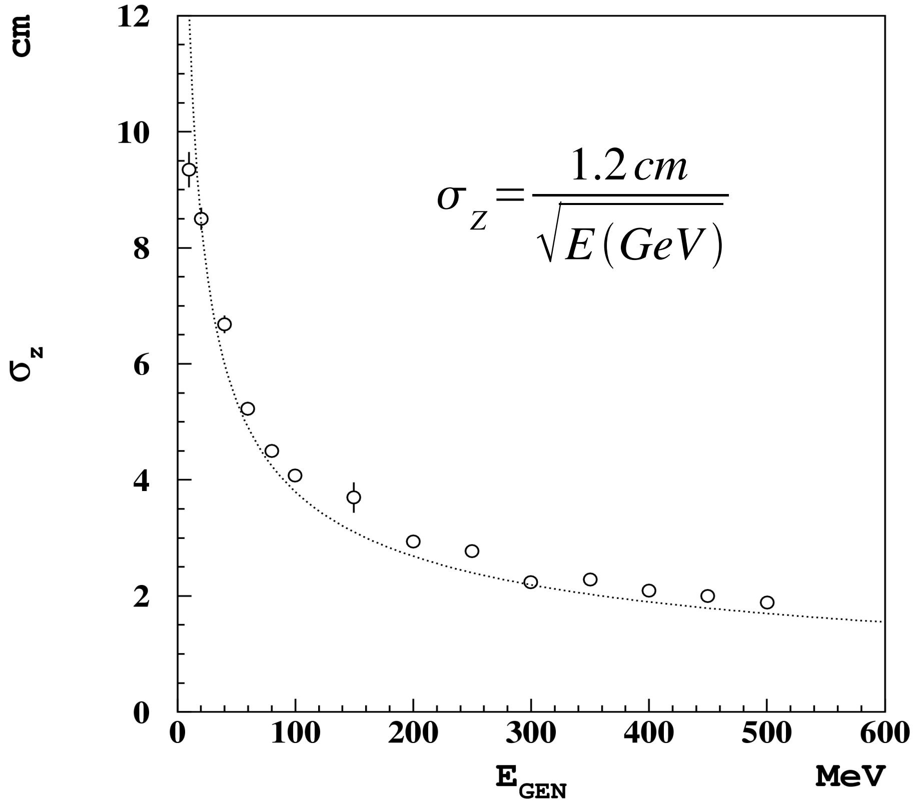
CLUSTER POSITION – longitudinal resolution

The curve is the known detector response, dots FLUKA simulation

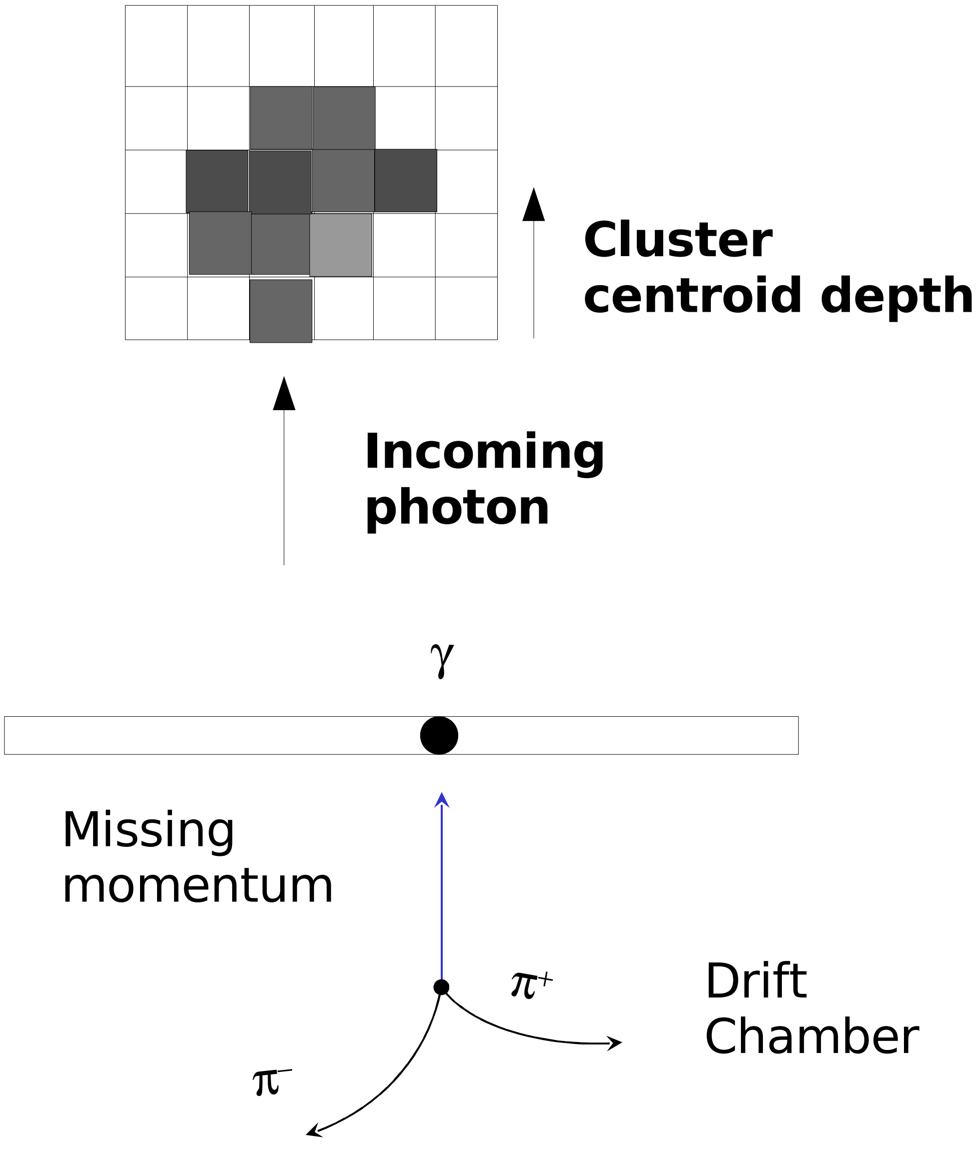
Resolution of the cluster centroid position of the along the module.

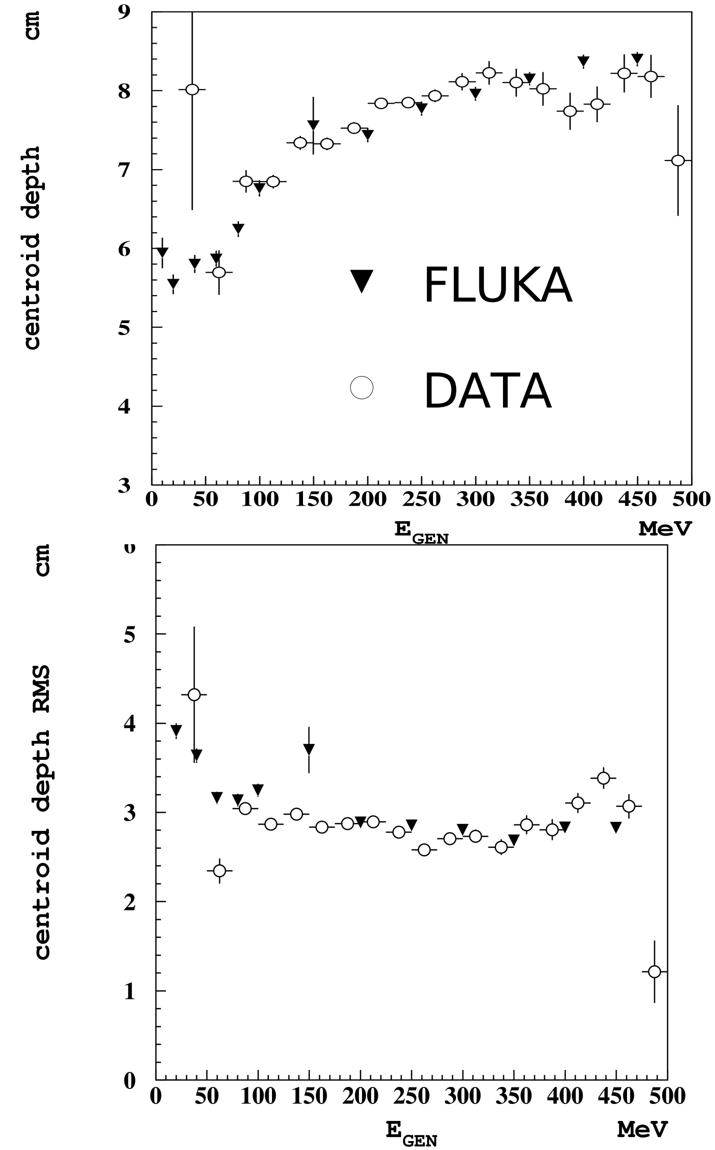


$$Z = \frac{(t_A - t_B)\, v_{light}}{2}$$



e.m. shower penetration depth





Conclusions

- we are using FLUKA to simulate the spaghetti structure of the KLOE calorimeter in order to perform optimization study;
- the response to EM shower seems very good, no fine tuning of parameters was needed in order to reproduce energy and cluster position resolution;
- the response to π, μ is under study;
- we plan to simulate the whole KLOE calorimeter and test also the K_L interaction.

π^+/μ^+ response